

# GENE SEGREGATIONS, LINEAR BODY MEASUREMENTS AND PERFORMANCE EVALUATION OF DAIRY CATTLE CROSSBREEDING IN NORTHWESTERN ETHIOPIA

Addis GETU<sup>✉1</sup>, Tadese GUADU<sup>2</sup>, Shewangizaw ADDISU<sup>1</sup>, Asechalew ASSEFA<sup>1</sup>, Nibrete MOGESE<sup>3</sup>, Mersha CHANIE<sup>4</sup>, Basazenew BOGALE<sup>4</sup>, Malede BIRHANU<sup>1</sup>, Atnaf ALEBIE<sup>5</sup>, and Atsedewoyne FEREBSEBHATE<sup>5</sup>

Department of (<sup>1</sup>Animal Production and Extension, <sup>2</sup>Environmental and Occupational Health and Safety, <sup>3</sup>Veterinary Clinical Medicine, <sup>4</sup>Para Clinical Study, <sup>5</sup>Basic Science in the Faculty of Veterinary Medicine), University of Gondar, Ethiopia

<sup>✉</sup>Email: addisgetu2002@yahoo.com

**ABSTRACT:** An investigative research work was delivered to address the objective of characterizing the cross breeding effects on dairy cattle performances in North West Ethiopia (North Gondar, South and west Gojam). In the same time, exploratory field survey and multistage sampling technique was conducted to collect the polygenic traits and improvement effects of cross breeding in the study areas. Blood level like F<sub>1</sub> (50E:50L), F<sub>2</sub> (25E:75L), F<sub>3</sub> (75E:25L) and F<sub>4</sub> (12.5E:87.5L) dairy cattle characterization work was conducted from north Gondar, south Gondar and west Gojam zone. The interaction effect of body weight and other liner body measurements for all dairy cows with different blood levels were highly significant ( $P < 0.01$ ). Body weight and body length at F<sub>3</sub>, F<sub>2</sub>, F<sub>1</sub> and F<sub>4</sub> blood levels of the cows were indicated that none, little and significant ( $P < 0.01$ ) reduction were observed on the measurable trait values across the blood levels like body weight least square mean value of 405.86, 405.72, 401.38 and 346.13 (kg) and 184.78, 182.32, 178.68 and 169.59<sup>b</sup> (cm) for body length, respectively. Whereas, performances of cows were reduced as exotic blood levels were increased. So, this work remarked that F<sub>1</sub> generation of an animal had superior in different aspects, while the gene segregation effect was observed at F<sub>3</sub> (75E:25L) generation. Similarly, the factorial ANOVA indicated that peak milk yield (12.83lt/day) was measured from parity three and F<sub>1</sub> generations. Therefore, gene segregation and down crossing effect could be the causes of economic losses and should be flew the bloods through generations. In addition, characterization of the randomly disseminated genetic resources should be employed to evaluate and know the breeding practices and effect of the merit or demerits of cross breeding in the country.

**Keywords:** Measurable Traits, Crossbreeding, Genetic Improvement, Cattle, Amhara

## INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa, of roughly 53.99 million animals out of this total cattle population, the female cattle constitute about 55.48% and the remaining 44.52% are male cattle. In Ethiopia, large livestock population plays an important socio economic roles and contributing about 12% of the Gross Domestic Product (GDP). According to FAO (2005) and CSA (2011) in Amhara region, about 28% of the animal population was females of which about 55% of Ethiopian total cattle population and produces about 3.2 and 0.82 billion liters of milk per year in Ethiopia and in Amhara region, respectively are produced The average lactation milk production for the indigenous cows is ranged from 494–850 liters per 1.5 years with 1.54 liters per cow per day (CSA, 2007).

Performance potentials of local cattle are relatively low and crossbreeding with *B. Taurus* was recommended to improve their productive and reproductive performances. Consequently, in Ethiopian history, domestication and the use of conventional livestock breeding techniques for genetic improvement of dairy cattle to enhance milk

ORIGINAL ARTICLE  
 pii: S222877011700014-7  
 Received 15 Jun. 2017  
 Accepted 18 Jul. 2017

production of local breeds is over about six decades (Leakey, 2009). It also appears important to estimate the expected level of heterosis for traits of economic interest in dairy cattle in order to evaluate the profitability of crossbreeding (Mauro et al., 2009). This program was launched during the invasion of Ethiopia by Italy with importation of exotic dairy cattle breeds.

Later on, the first livestock development project (1958-1963) created the Dairy Development Agency (DDA) that was concerned mainly with the development of commercial dairy farms in Addis Ababa (Fekadu, 1990). Following this Chilalo Agricultural Development Project (CADU), an integrated project established jointly by the Ethiopian and Swedish Governments, in Arsi region initiated intensive small scale dairy development in Ethiopia in 1967/68 was established (Kiwuwa et al., 1983). This was followed by the Wolaita Agricultural Development Project (WADU) that was established in 1971 and funded by the World Bank, applied the CADU program (Hailemariam, 1994). The focus of the program was on increasing the milk productivity of local breeds through crossbreeding and distribution of F<sub>1</sub> heifers to farmers (EARO, 2001).

Linear body measurement has positive correlation to evaluate the performance improvement trends of dairy cattle. In addition, crossbreeding has resulted in good improvements in production of milk especially when supplemented with adequate management levels in terms of nutrition and disease controls. In spite of, the presence of large and diverse animal genetic resources, the productivity of livestock remains low in many regions of the country (Fikre, 2007). However, genetic improvement effect and gene segregation trend on different blood level with the phenotype of the animal is not identified. Therefore, the extents of exotic genotypes have been diffused into the indigenous populations, significance importance on dairy genetic improvement, and its progress and the level of dilution is not independently assessed. The objective of the study was to put a bench mark on the gene segregations effects, linear body measurements and performance evaluation of dairy cattle crossbreeding in North West Ethiopia.

## MATERIALS AND METHODS

### Description of the study area

The study was conducted in three zones and 9 districts of Amhara regional state from 2015 to 2016. Amhara National Regional State (ANRS) is located in the north-western part of Ethiopia. Geographically, it is situated between latitude 9°–13°45'N and longitude 36°–40°30'E. It is bounded by the Afar, Benishangul, Oromiya and Tigray regions in the east, south-west, south and north, respectively, and by Sudan in the west. The total area of the region is estimated at 170,152 km<sup>2</sup>, which is about one-sixth of the country's total area (Gizaw et al., 2013). The region ranges from 600 m.a.s.l (meter above sea level) at Metema and 4520 m.a.s.l at Ras Dashen, North Gondar, which is also Ethiopia's highest point. The wide range of altitude is a major factor in determining the temperature range of the region. Generally, lowland areas (<1500 m a.s.l.) experience hot temperatures, while highland areas (>1500 m a.s.l.) experience relatively cooler temperatures. For example, in the hot to warm sub moist agro-ecological zone, where the altitude ranges from 600 to 1400 m a.s.l., the mean annual temperature range is 21–27°C while in the cold to very cold moist zone, where the altitude ranges from 2800 to 4200 m a.s.l., the mean annual temperature varies from 7.5°C to 16°C (CSA, 2007).

Exploratory approach as a study design and multistage sampling techniques like both purposive and random sampling methods were considered. Based on the blood levels and crossed dairy cattle potential, the 3 zones were selected. From the total 180 households about 150 matured crossed dairy cattle were used for the study (FAO, 2011). Both qualitative like blood level of dairy cattle, parity and sex of the owners and quantitative data like body length (BL), body weight (BWT), tail length (TL), heart girth circumference (HGC), high at wither and high at hip (HAH) were considered. Similarly, systematic simple random sampling technique was used to select the crossed dairy cattle owners. General linear model was developed using meter and heart girth as a measurable tool for linear body measurements and body weight of an animal with the fixed effect of blood level and parity. While, data were analyzed using SAS software (SAS, 2002).

---


$$\text{Model: } 1. Y_{ijk} = \mu + A_i + D_j + AD_{ij} + e_{ijk}$$


---

$Y_{ijk}$  = the observed milk yields of the cattle

$\mu$  = overall mean

$A_i$  = fixed effect of  $i^{\text{th}}$  type ( $n$  = cattle blood levels)

$D_j$  = the effect of  $k^{\text{th}}$  parity ( $j$  = 1-4)

$AD_{ji}$  = the fixed effect interaction  $i^{\text{th}}$  of blood level with  $j^{\text{th}}$  of parity

$e_{ijk}$  = random residual error

## RESULTS AND DISCUSSIONS

### Performance of hybrid dairy cattle

Average productive and reproductive performance of different blood levels of dairy cattle in the region were characterized under different production systems using measurable traits. About 25, 20.1 and 20% of the interviewed owners were females from north Gondar, west Gojam and south Gondar zone, respectively. While the majority of the respondents about 75% were fully involved in small scale mixed crop-livestock in peri urban and urban types of crop-livestock production systems and used cattle as source of income for immediate expenses such as purchasing of salt, coffee, clothe and animals' medicine. Most of the cows held on peri urban and urban farms were lactating during the study period, while higher percentages of dry cows were observed on rural small scale farms. Milking, processing, cleaning and selling of dairy products such as milk and butter was performed by adult males and females. Most of the information was generated from males which indicated that mainly men are responsible for rearing of dairy cows.

According to the respondents' point of view good performance of dairy cows could be attributed to genetic and non-genetic factors such as blood level, supplementary feed and care of farmers to their animals. The present finding discovered that parity had significant cause of variation for the performances of milk production with the least square mean value of  $4.90 \pm 0.34$ ,  $6.56 \pm 0.44$ ,  $8.58 \pm 0.71$  and  $8.55 \pm 1.12$  litter/day for P1-P4, respectively. While blood level was one of the fixed effects of dairy cattle performances with the average peak milk yield and gene segregation signs average mean value of  $12.8^a$ ,  $12.0^a$ ,  $11.07^a$  and  $8.57^b$  litters of milk per day for F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub> and F<sub>4</sub> generation, respectively.

Average productive and reproductive performances of hybrid dairy cattle and their significant difference were estimated under existing farmers' management condition (Table 1). In this result, average milk yield of F<sub>1</sub> hybrid dairy cattle was much higher than 5.9 and 6.4 litter/day reported by Addis et al (2015) and Belay et al (2012), respectively. The performance of milk yield in the hybrid dairy cattle obtained from the present study was higher in F<sub>1</sub> (9.59 litters/cow/day) but smaller in 6.82 litters/cow/day where gene segregation was observed from F<sub>2</sub> and F<sub>3</sub> even if hetrosis effect is expressed on the local dairy cows like 9.12 and 8.15 litters/day/crossed breed than 1.54 litter/day/local cows, respectively. However, higher milk yield performance was record from monitored cows in F<sub>1</sub> generation reported by Addis et al (2015) with F<sub>1</sub> daily milk yield of 11 liters. Another study conducted in North Showa zone indicated that 50% cross breeds were produced 1511.5 litter of milk per lactation which was more amount of milk than local breeds (457.89 L) (Mulugeta and Belayneh, 2013).

This variation from the pure breed is indicative for the better performance of the hybrid and existence of variability in milk production could be an indication of the potential for genetic improvement through cross breeding followed by selection with selected indigenous superior dairy cattle.

**Table 1. Current production systems and Performance aspect of dairy cattle in different blood levels in Amhara Ethiopia (least square mean)**

Blood Level	Milk Yield				Overall
	P1	P2	P3	P4	
F1	5.63 <sup>bc</sup>	9.43 <sup>a</sup>	12.83 <sup>a</sup>	10.45 <sup>a</sup>	9.59
F2	6.71 <sup>a</sup>	9.10 <sup>a</sup>	12.0 <sup>a</sup>	8.65 <sup>b</sup>	9.12
F3	6.02 <sup>ab</sup>	7.64 <sup>b</sup>	11.07 <sup>a</sup>	7.88 <sup>b</sup>	8.15
F4	4.90 <sup>c</sup>	6.55 <sup>b</sup>	8.57 <sup>b</sup>	7.25 <sup>b</sup>	6.82
Overall Mean	4.90-0.34	6.56-0.44	8.58-0.71	8.55-1.12	8.42

F<sub>1</sub>= 50E:50L, F<sub>2</sub>= 25E:75L, F<sub>3</sub>= 75E:25L, F<sub>4</sub>= 12.5E:87.5L, P= parity

### Interaction effect of fixed factors to quantitative parameters

From the total sampled dairy cattle with 8 measurable parameters such as BWT (kg), BL (cm), HGC (cm), HAG (cm), HAH (cm), TL (cm) and teat length in cm for different blood level were considered. The GLM least squares mean of body weight and liner body measurements of F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub> and F<sub>4</sub> hybrid dairy cattle with their variations and comparison test was stated. The overall mean square of body weight obtained for F<sub>1</sub> - F<sub>3</sub> hybrid dairy cattle were significantly ( $P < 0.05$ ) heavier in body weight than F<sub>4</sub> generations. Whereas, F<sub>1</sub> dairy cattle generations had better different aspects than other blood levels. Even if the hetrosis effect is dominant at the interaction effect indicated that serious gene segregation effect was observed at F<sub>4</sub> generation.

Thus, F<sub>1</sub> in body length associated with milk yields were found to significantly long with the value of 184.78<sup>a</sup> which is relatively taller than the report of Yan et al. (2009) who stated that the body length of F<sub>2</sub> crossed one was 146.37 cm. However, F<sub>2</sub> and F<sub>3</sub> had bigger body weight 405.72 and 405.86 than F<sub>1</sub> and F<sub>4</sub> generations,

respectively. The overall mean for body weight trend obtained for mature cows at F<sub>1</sub> up to F<sub>4</sub> generations were 389.77 (kg), which was heavier than other Ethiopian local cattle.

**Table 2 - Comparison least square mean (Lsm) of body weight (kg) and linear body measurements (cm) of the hybrid dairy cattle in Amhara Ethiopia**

Blood level	BL	BWT	TL	HGC	HAW	HAH	Teat length
F <sub>1</sub>	184.78 <sup>a</sup>	401.38 <sup>a</sup>	87.38 <sup>b</sup>	166.50 <sup>ab</sup>	130.50 <sup>ab</sup>	133.88 <sup>a</sup>	7.38 <sup>a</sup>
F <sub>2</sub>	182.32 <sup>a</sup>	405.72 <sup>a</sup>	125.18 <sup>a</sup>	170.77 <sup>ab</sup>	132.27 <sup>a</sup>	135.09 <sup>a</sup>	6.77 <sup>ab</sup>
F <sub>3</sub>	178.68 <sup>ab</sup>	405.86 <sup>a</sup>	85.18 <sup>b</sup>	173.77 <sup>a</sup>	133.22 <sup>a</sup>	134.09 <sup>a</sup>	6.36 <sup>b</sup>
F <sub>4</sub>	169.59 <sup>b</sup>	346.13 <sup>b</sup>	84.81 <sup>b</sup>	164.86 <sup>b</sup>	127.22 <sup>b</sup>	123.79 <sup>b</sup>	7.04 <sup>ab</sup>
Over all hybrid	178.84	389.77	95.64	168.97	130.80	131.71	6.89

F<sub>1</sub>= 50E:50L, F<sub>2</sub>= 25E:75L, F<sub>3</sub>= 75E:25L, F<sub>4</sub>= 12.5E:87.5L, BL= body length, BWT= body weight, TL= teal length, HGC= heart girth circumference, HAW= high at weather and HAH= high at hip

## CONCLUSION AND RECOMMENDATIONS

The overall trends of cattle crossbreeding and its effect on body measurement via dependant variables on local dairy cattle in North West Ethiopia was stated. Following that the performance of local dairy cows are reached at peak at F<sub>1</sub> blood level and gene segregation effect is started at F<sub>3</sub> generations. Therefore, the breeding strategy of the country is better to assess the breeding program and focused on the levels of gene segregation effects.

### Acknowledgements

Finally, we would like to thank the University of Gondar for its contribution on budget and time support. We would also like to acknowledge all authors for their contribution to develop the proposal, collect data, analysis and the preparation of the manuscript. We also pass our acknowledge to Abaye Ashagerew, Tadegegne Mitiku and Yalew Demewoze who had collected the necessary data from the cattle owners and experts who were participated in the research work.

### Author's contribution

All authors contributed equally to this work.

### Competing Interests

The authors declare that they have no conflict of interest with respect to the research, authorship or publications of this article.

## REFERENCES

- Addis G, Goshu B and Derb A (2015). Cross breeding effect on the performance of indigenous cattle: challenges and opportunities. *Journal of Agricultural Science and Food Technology*, 1(2): 16-21.
- Belay D, Yisehak K and Janssens G (2012). Productive and reproductive performance of zebu x Holstein-Friesian crossbred dairy cows in Jimma town, Oromia, Ethiopia. *Global Veterinarian*, 8(1): 67-72, 2012.
- CSA (2007). Population and housing census of Ethiopia: statistical report for Amhara region. Pp. 1-25. In Part I: Population size and characteristics.
- CSA (2011). Agricultural sample survey 2010/11, 2: statistical bulletin 505. Report on livestock and livestock characteristics (prevent peasant holdings), Addis Ababa, February 2011.21.
- Ethiopian Agricultural Research Organization (EARO) (2001). Back ground paper on developing animal breeding policy working paper. January, 2001, pp. 21.
- FAO (Food and Agriculture Organization of the United Nations) (2011). Guideline for the In Vivo Conservation of Animal Genetic Resources. Rome (Draft).
- FAO (Food and Agriculture Organization of the United Nations) (2005). *Production yearbook*. FAO, Rome, Italy.
- Fekadu G (1990). Pastoral nomadic and rural development. In: Ethiopia: Rural Development Options.
- Fikre L (2007). Reproductive and lactation performance of dairy cattle in the oromia central highlands of ethiopia with special emphasis on pregnancy period. Doctoral thesis, Swedish University of Agricultural Sciences, Uppsala.

- Hailemariam M (1994). Genetic analysis of Boran, Friesian and crossbred cattle in Ethiopia. A PhD thesis submitted to the Swedish University of Agricultural Sciences, Department of Animal Breeding and Genetics, Sweden.
- Kiwuwa GH, Trail JCM, Kurtu MY, Getachew W, Anderson MF, Durkin J (1983). Crossbred dairy productivity in Arsi Region, Ethiopia. ILCA Research Report No. 11, ILCA, Addis Ababa,
- Leakey R (2009). Impacts of AKST (Agricultural Knowledge Science and Technology) on development and sustainability goals. In *Agriculture at a crossroads* (eds B.D. McIntyre, H.R. Herren, J. Wakhungu & R.T. Watson), pp. 145–253. Washington.
- Mauro P, Riccardo Dal Z, Nicolás López-Villalobos and Martino C (2009). Crossbreeding effects in dairy cattle; PhD Dissertation: Genetica, Biodiversità, Biostatistica E Biotecnologie Ciclo XXI, Università Degli Studi Di Padova.
- Mulugeta A and Belayeneh A (2013). Reproductive and lactation performances of dairy cows in Chacha town and nearby selected kebeles, north Shoa zone, Amhara region, Ethiopia. *World J. A.*
- SAS (2002). Statistical Analysis System (SAS), SAS Users<sup>™</sup> Guide, Version 9.1, (SAS Institute Inc, North Carolina).
- Yan T, Mayne CS, Patterson DC, Agnew RE (2009). Prediction of body weight and empty body composition using body size measurements in lactating dairy cows. *Livestock Science*, 124: 233–241. doi: 10.1016/j.livsci.2009.02.003.
- Gizaw S, Abegaz S, Rischkowsky B, Haile A, Okeyo A and Dessie T (2013). Review of sheep research and development projects in Ethiopia. International livestock research institute (ILRI).